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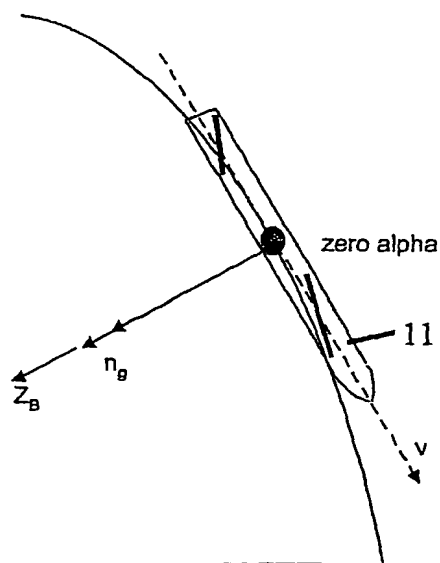
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(54) Title: CONTROL SYSTEM FOR CRAFT AND A METHOD OF CONTROLLING CRAFT



(57) Abstract: A control system for a missile (11) having a moving wing (12) and moving tail (13) which have synchronised operation for automated variable displacement. The system provides improved manoeuvrability allowing enhanced look and impact. The system is also applicable to aircraft, marine craft and UAV craft.

AMENDED CLAIMS

[received by the International Bureau on 15 October 2004 (15.10.04);
original claims 1 and 31 amended; remaining claims unchanged (10 pages)]

1. A control system for a craft having two wing control surfaces spaced apart along a main body section of the craft, the system comprising
5 automated synchronized operation of the two wing control surfaces for continuous variable displacement for manoeuvre of the main body relative to the flight path velocity vector with body directional control.
2. A control system for a craft according to Claim 1 comprising means
10 for automated synchronized operation of the two wing control surfaces to maintain continuous variable displacement of each wing control surface via independent actuation under the action of a control routine.
3. A control system for a craft according to Claim 1 or 2 comprising
15 means for independent actuation of both wings under a control routine involving a soft actuation mechanism.
4. A control system for a craft according to Claims 1 to 3 comprising means for a demand manoeuvre to act along an axis normal to a Zero Lift
20 Line and in the plane of manoeuvre.
5. A control system for a craft according to Claim 4 wherein the Zero Lift Line is that line co-incident with the local wind axis velocity vector, acting in the plane of manoeuvre in which the two wing control surfaces are
25 deflected and about which there is no net normal force and moment.
6. A control system for a craft according to any of Claims 1 to 5 comprising means to manoeuvre comprising additional automated synchronized control deflection of both wings acting normal to the Zero Lift
30 Line in the plane of manoeuvre under the action of a control routine.

7. A control system for a craft according to any of Claims 1 to 6 in which substantially all of a wing control surface is moveable under control actuation.

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8. A control system for a craft according to any of Claims 1 to 7 comprising an additional flap portion of a moving wing control surface for control.

10 9. A control system for a craft according to any of Claims 1 to 8 wherein the craft is an aircraft, marine craft or UAV and wherein the control routine is operable to continually control both wing control surfaces to manoeuvre the craft for optimal fuel efficiency.

15 10. A control system for a craft according to any of Claims 1 to 9 wherein the craft is an aircraft, marine craft or UAV and wherein the control routine is operable to continually control both wings control surfaces to manoeuvre the craft to maintain optimal forward directional visibility.

20 11. A control system for a craft according to any of Claims 1 to 8 wherein the craft is a guided missile or torpedo in which the control routine is operable to continually position the manoeuvring main body at an angle of incidence to the flight path velocity vector for optimal homing onto a target.

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12. A control system for a craft according to any of Claims 1 to 8 where the craft is a guided missile or torpedo in which the control routine is operable to drive the manoeuvring main body axis to coincide with the flight path velocity vector to achieve zero angle of incidence (zero grazing incidence) at target impact for maximum warhead effectiveness.

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13. A system according to any preceding claim wherein automated synchronised operation provides identical rotational and/or translational movement of the two wing control surfaces.

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14. A system according to any preceding claim wherein automated synchronised operation provides proportional rotational and/or translational movement of the two wing control surfaces.

10 15. A system according to any preceding claim wherein automated synchronised operation provides geared rotational and/or translational movement of the two wing control surfaces.

15 16. A system according to any preceding claim wherein automated synchronised operation provides variable rotational and/or translational movement of the two wing control surfaces.

17. A system according to any preceding claim wherein the craft comprises more than two wing control surfaces.

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18. A system according to any preceding claim wherein substantially all of a control surface is moveable under the automated synchronised operation.

25 19. A system according to any preceding claim wherein a flap portion of a wing control surface is moveable under the automated synchronised operation.

20. A system according to any of Claims 1 to 10 and 13 to 19 wherein
30 the craft comprises an aircraft.

21. A system according to any of Claims 1 to 10 and 13 to 19 wherein the craft comprises a marine craft.
- 5 22. A system according to any of Claims 1 to 8 and 11 to 19 wherein the craft comprises a missile.
23. A system according to any of Claims 1 to 8 and 11 to 19 wherein the craft comprises a torpedo.
- 10 24. A system according to any preceding claim wherein the craft is unmanned.
25. A system according to any preceding claim comprising means to off-
15 set the body axis relative to the instantaneous flight path velocity vector.
26. A system according to any preceding claim comprising means to effect an applied manoeuvre about an instantaneous Zero Lift Line.
- 20 27. A system according to any preceding claim comprising means to maintain constant speed V .
28. A system according to any preceding claim comprising means to adjust, at an instant in time, the control surfaces setting to effect
25 configuration of the Zero Lift Line and initiate manoeuvre relative to the Zero Lift Line in any plane of manoeuvre.
29. A system according to any preceding claim having a controller to provide, selectively as required:-
30 constant speed;

- variable speed;
proportional rotation and/or translation movement of control surfaces
under independent actuation;
geared rotational and/or translational movement of control surfaces
5 under independent actuation;
variable rotational and/or translational movement of control surfaces
under independent actuation.

30. A craft having a control system according to any one or more of
10 Claims 1 to 29.

31. A method of controlling a craft having two wing control surfaces
spaced apart along a main body section of the craft, the method comprising
automated synchronized operation of the two wing control surfaces for
15 continuous variable displacement for manoeuvre of the main body relative
to the flight path velocity vector with body directional control.

32. A method of controlling a craft according to Claim 31 comprising
automated synchronized operation of the two wing control surfaces to
20 maintain continuous variable displacement of each wing via independent
actuation under the action of a control routine.

33. A method of controlling a craft according to Claim 31 or 32
independent actuation of both wings under a control routine and involving
25 operation of a soft actuation mechanism .

34. A method of controlling a craft according to any of Claims 31 to 33
comprising a demand manoeuvre acting along an axis normal to a Zero Lift
Line and in the plane of manoeuvre is implemented.

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35. A method of controlling a craft according to Claim 34 the Zero Lift Line is that line co-incident with the local wind axis velocity vector, acting in the plane of manoeuvre in which the two wings are deflected and about which there is no net normal force and moment.

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36. A method of controlling a craft according to any of Claims 31 to 35 comprising additional automated synchronized control deflection of both wings acting normal to the Zero Lift Line in the plane of manoeuvre under the action of a control algorithm.

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37. A method of controlling a craft according to any of Claims 31 to 36 comprising moving substantially all of a wing control surface under control actuation.

15 38. A method of controlling a craft according to any of Claims 31 to 37 comprising moving an additional flap portion of a wing control surface for control.

39. A method of controlling a craft according to any of Claims 31 to 38
20 wherein the craft is an aircraft, marine craft or UAV and comprising continually controlling both wing control surfaces to manoeuvre the craft for optimal fuel efficiency.

40. A method of controlling a craft according to any of Claims 31 to 38
25 wherein the craft is an aircraft, marine craft or UAV and comprising continually controlling both wing control surfaces to manoeuvre the craft for optimal forward directional visibility.

41. A method of controlling a craft according to any of Claims 31 to 38
30 wherein the craft is a guided missile or torpedo and comprising continually

positioning the manoeuvring main body at an angle of incidence to the flight path velocity vector for optimal homing onto a target.

42. A method of controlling a craft according to any of Claims 31 to 38
5 wherein the craft is a guided missile or torpedo and comprising driving the manoeuvring main body axis to coincide with the flight path velocity vector for zero angle of incidence (zero grazing incidence) at target impact for maximum warhead effectiveness.

10 43. A method of controlling according to any of Claims 31 to 42 wherein automated synchronised operation provides identical rotational and/or translational movement of the two wing control surfaces.

44. A method of controlling according to any of Claims 31 to 43
15 comprising automated synchronised operation to provide proportional rotational and/or translational movement of the two wing control surfaces.

45. A method of controlling according to any of Claim 31 to 44
20 comprising automated synchronised operation to provide geared rotational and/or translational movement of the two wing control surfaces.

46. A method of controlling according to any of Claims 31 to 45
comprising automated synchronised operation to provide variable rotational and/or translational movement of the two wing control surfaces.

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47. A method of controlling according to any of Claims 31 to 46
comprising moving more than two wing control surfaces.

48. A method of controlling according to any of Claims 31 to 47 comprising moving substantially all of a control surface moveable under the automated synchronised operation.
- 5 49. A method of controlling according to any of Claims 31 to 47 comprising moving a flap portion of a wing control surface under the automated synchronised operation.
50. A method of controlling according to any of Claims 31 to 40 and 43
10 to 49 wherein the craft comprises an aircraft.
51. A method of controlling according to any of Claims 31 to 40 and 43 to 49 wherein the craft comprises a marine craft.
- 15 52. A method of controlling according to any of Claims 31 to 38 and 41 to 49 or 51 wherein the craft comprises a missile.
53. A method of controlling according to any of Claims 31 to 38 and 41 to 49 or 52 wherein the craft comprises a torpedo.
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54. A method of controlling according to any of Claims 31 to 53 wherein the craft is unmanned.
55. A method of controlling according to any of Claims 31 to 54
25 comprising off-setting the body axis relative to the instantaneous flight path velocity vector.
56. A method of controlling according to any of Claims 31 to 55 comprising effecting an applied manoeuvre about an instantaneous Zero
30 Lift Line.

57. A method of controlling according to any of Claims 31 to 56 comprising maintaining constant speed V.

5 58. A method of controlling according to any of Claims 31 to 57 comprising adjusting, at an instant in time, the control surfaces setting to effect configuration of the Zero Lift Line and initiate manoeuvre relative to the Zero Lift Line in any plane of manoeuvre.

10 59. A method of controlling according to any of Claims 31 to 58 comprising operating a controller to provide, selectively as required:-
constant speed;
variable speed;
proportional rotation and/or translation movement of control surfaces
15 under independent actuation;
geared rotational and/or translational movement of control surfaces under independent actuation;
variable rotational and/or translational movement of control surfaces under independent actuation.

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60. A craft having a method of control according to any one or more of Claims 31 to 59.

25 61. A computer program product directly loadable into the internal memory of a digital computer, comprising software code portions for performing the method of any one or more of Claims 31 to 59 when said product is run on a computer.

30 62. A computer program directly loadable into the internal memory of a digital computer, comprising software code portions for performing the

method of any one or more of Claims 31 to 59 when said program is run on a computer.

63. A carrier, which may comprise electronic signals, for a computer
5 program of Claim 62.

64. Electronic distribution of a computer program product of Claim 61 or a computer program of Claim 62 or a carrier of Claim 63.

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